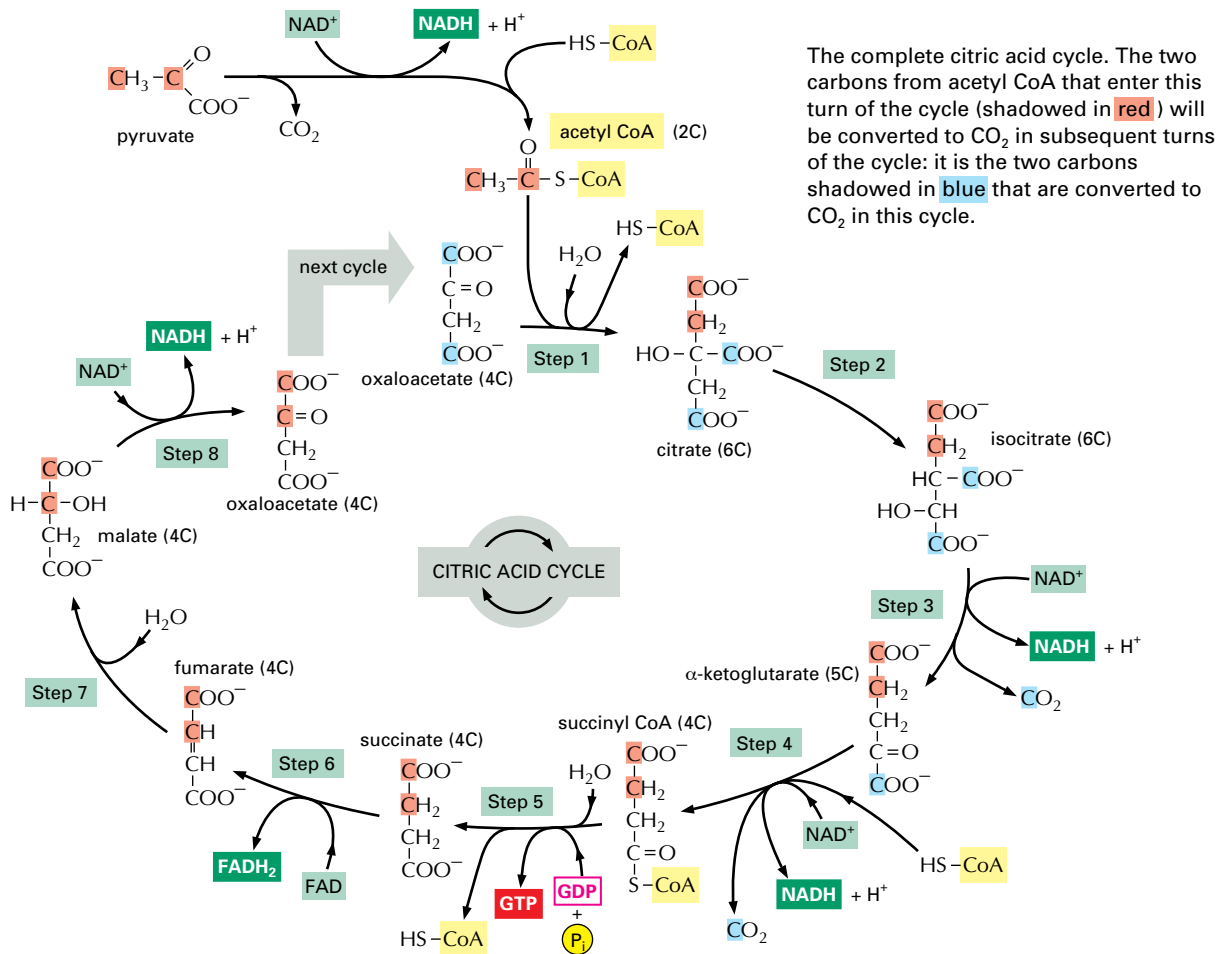


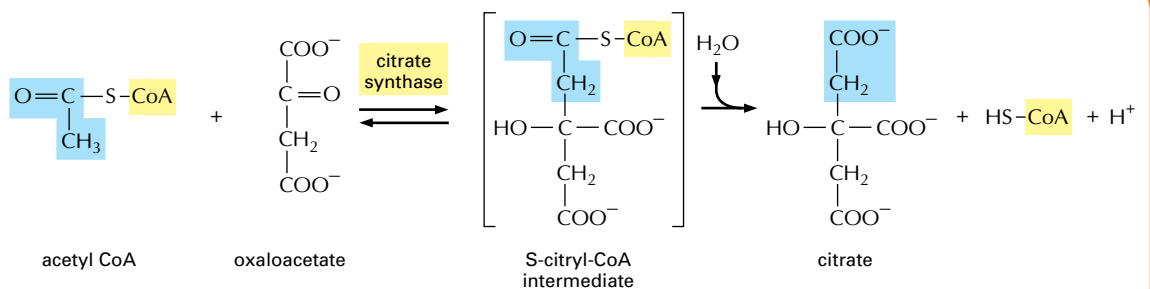
Panel 13-2 The complete citric acid cycle



Details of the eight steps are shown below. For each step, the part of the molecule that undergoes a change is shadowed in blue, and the name of the enzyme that catalyzes the reaction is in a yellow box.

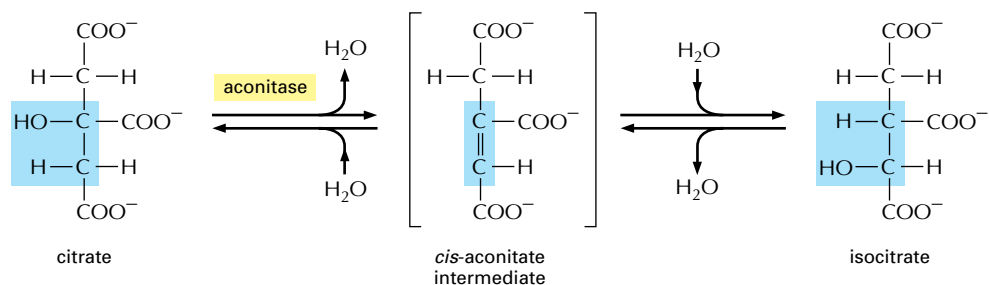
Step 1

After the enzyme removes a proton from the CH₃ group on acetyl CoA, the negatively charged CH₂⁻ forms a bond to a carbonyl carbon of oxaloacetate. The subsequent loss by hydrolysis of the coenzyme A (CoA) drives the reaction strongly forward.



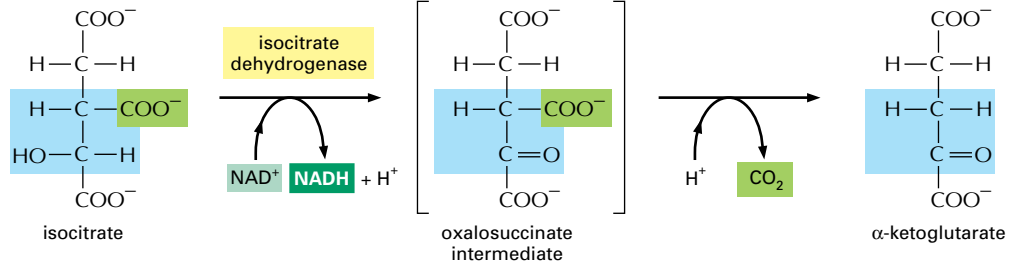
Step 2

An isomerization reaction, in which water is first removed and then added back, moves the hydroxyl group from one carbon atom to its neighbor.

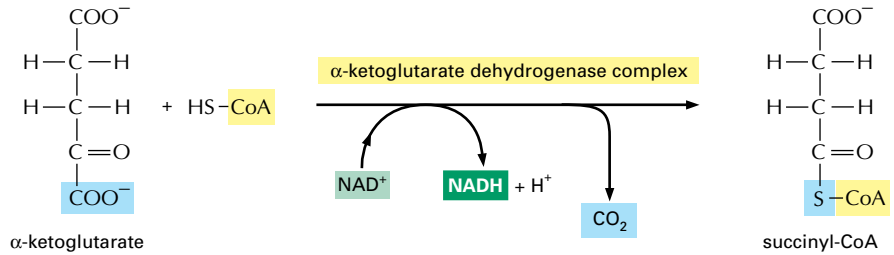


Step 3

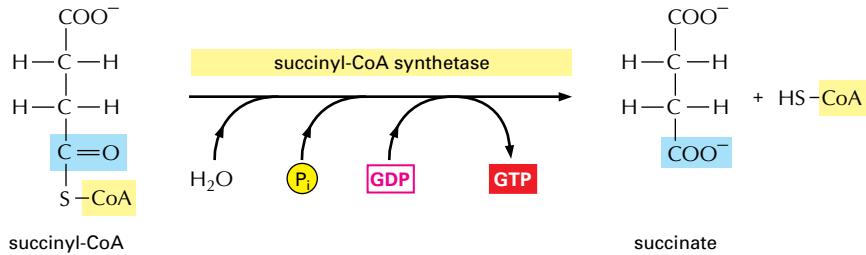
In the first of four oxidation steps in the cycle, the carbon carrying the hydroxyl group is converted to a carbonyl group. The immediate product is unstable, losing CO_2 while still bound to the enzyme.

**Step 4**

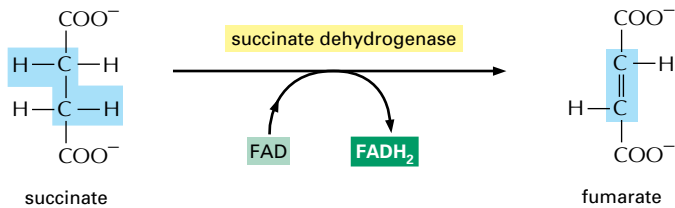
The α -ketoglutarate dehydrogenase complex closely resembles the large enzyme complex that converts pyruvate to acetyl CoA (pyruvate dehydrogenase). It likewise catalyzes an oxidation that produces NADH , CO_2 , and a high-energy thioester bond to coenzyme A (CoA).

**Step 5**

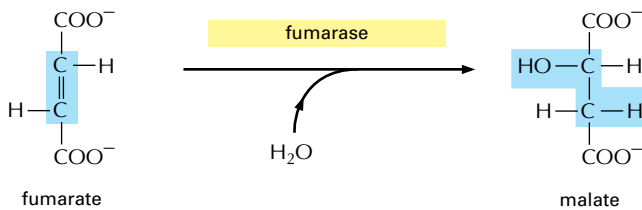
A phosphate molecule from solution displaces the CoA, forming a high-energy phosphate linkage to succinate. This phosphate is then passed to GDP to form GTP. (In bacteria and plants, ATP is formed instead.)

**Step 6**

In the third oxidation step in the cycle, FAD removes two hydrogen atoms from succinate.

**Step 7**

The addition of water to fumarate places a hydroxyl group next to a carbonyl carbon.

**Step 8**

In the last of four oxidation steps in the cycle, the carbon carrying the hydroxyl group is converted to a carbonyl group, regenerating the oxaloacetate needed for step 1.

